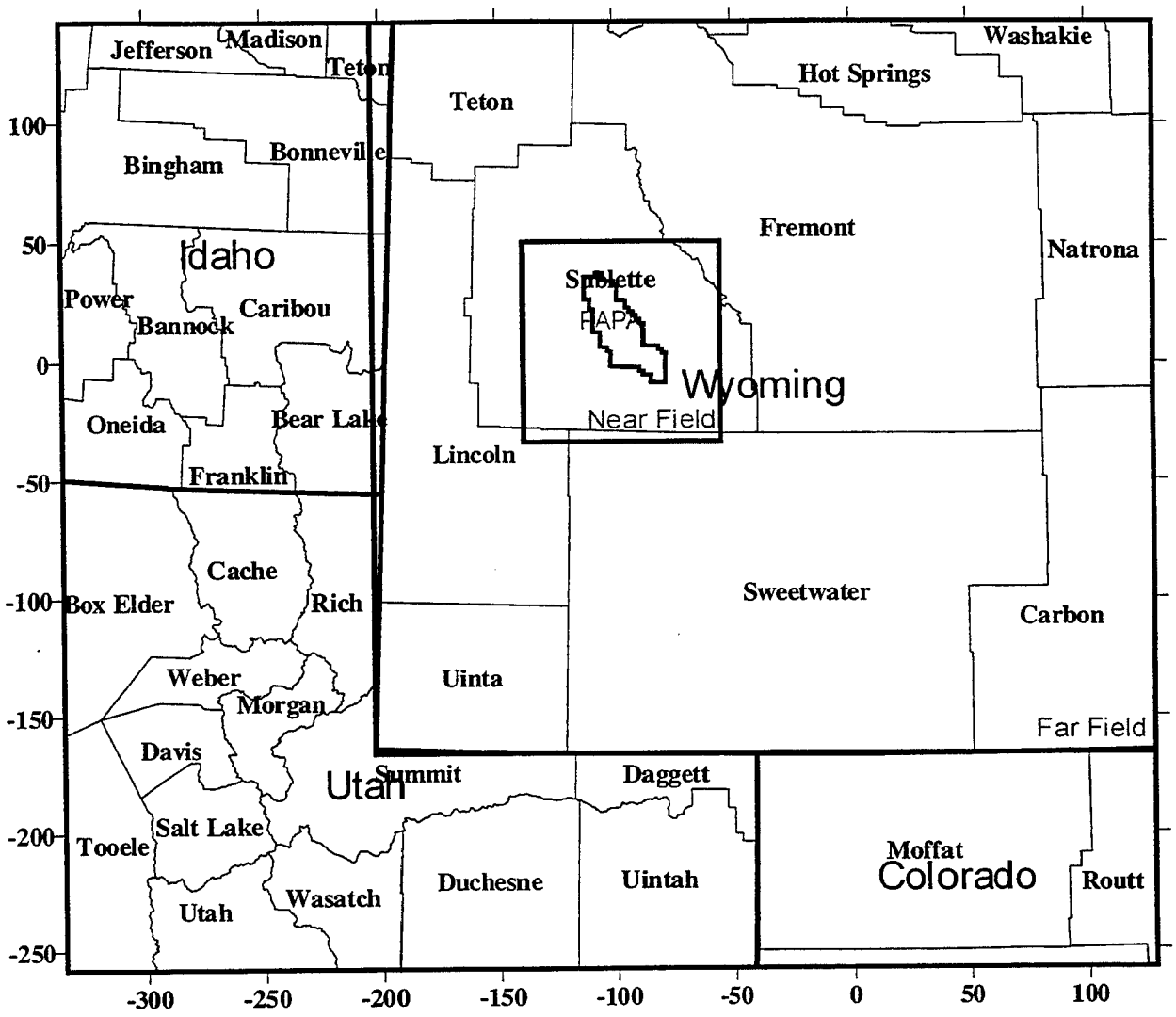
4. CALPUFF MODELING

The CALPUFF model (Version 5, Level 990228) was applied to an area in southwest Wyoming to estimate the near-source and far-field air quality and air quality related value (AQRV) impacts of new pollutant emissions from natural gas wells, well construction, and compression associated with the Pinedale Anticline Project. Additional analysis was also performed to assess the contribution of sources permitted since July 1, 1995 and any reasonable foreseeable development sources (i.e., post-95 sources), as well as cumulative impacts due to the combined Project and post-95 sources. The near-source and far-field modeling also estimated the total concentration impacts due to the existing background (current 1995 sources) plus the post-95 and Project contributions.

For the near-source CALPUFF modeling, the Project, post-95, and cumulative concentration impacts and total concentrations (cumulative contribution plus existing background) were estimated within and in the vicinity (out to 5-km from the boundaries) of the Pinedale Anticline Project area. The near-source concentration estimates due to the Project and post-95 sources were compared with the PSD Class II increments. The near-source total concentration estimates (cumulative contribution plus background) were compared against National and Wyoming Ambient Air Quality Standards (NAAQS and WAAQS).

The far-field modeling estimated impacts on air quality, visibility, and acid deposition at nearby Class I and Class II sensitive areas. The far-field concentration estimates due to the Project and post-95 sources were compared with the PSD Class I and II increments (depending on whether the receptor is located in a PSD Class I or II area). The far-field total concentrations (cumulative contribution plus background) were compared against the NAAQS and WAAQS. Visibility impacts were assessed using the approach recommended by the land managers (FLAG/IWAQM recommended approach), where the background visibility is based on the mean of the 20 percent cleanest days of the IMPROVE reconstructed mass measurement data. The acid deposition impacts were assessed using the Fox Acid Neutralizing Capacity (ANC) approach recommended by the USDA Forest Service (FS).

Figure 4-1 displays the CALMET/CALPUFF modeling domain used in the Pinedale Anticline Project EIS air quality modeling. CALMET was exercised for the entire modeling domain, whereas for the far-field modeling and post-95 sources near-source modeling CALPUFF was exercised for the southwestern Wyoming modeling domain. For the near-source modeling of the Project sources, a smaller modeling domain (near-field) was used.



Lambert Conformal Projection
SW-NE corners = (-335, -258) to (129,142)
Projection center lat/long = 42.55, -108.55
True latitudes: 30., 60.

Far Field (-203, -166) to (129,142)
Near Field (-139,-34) to (-55, 50)

Figure 4-1. CALMET Pinedale Anticline Project EIS modeling domain. Also shown is the near-source CALPUFF modeling domain (near-field) for the Project sources and the far-field Southwestern WY CALPUFF modeling domain.

NEAR-SOURCE CALPUFF MODELING

For the near-source modeling, the maximum hourly emission estimates for the Project were used to analyze the short-term (≤ 24-hour) pollutant concentration estimates. Seasonal maximum emission estimates for the Project were used for the long-term (annual) impact assessments. The Project is assumed to be operating with either 700 or 500 wells with construction and well operations assumptions as discussed in Chapter 3 and the "Pinedale Anticline Oil and Gas Exploration and Development Project Air Emissions Inventory" document (BLM, 1999). The CALPUFF modeling was performed for the 700 well scenario and the results for the 500 well scenario was obtained by ratio (5/7) from the 700 well operation scenario results. The longer-term (annual) modeling assumes that well operation emissions from dehydrators operate year round and emissions from separators only occurred during the colder months of November through April; it was assumed there were no emissions from separators from May through September.

The impacts due to the Project compressor operations were assessed for three locations and at three different NOx emission rates: 1.5 g/hp-hr, 1.0 g/hp-hr, and 0.7 g/hp-hr. The CALPUFF modeling of the compressors were performed at 1.0 g/hp-hr and the impacts due to the other two emission rates were obtained by scaling of the CALPUFF 1.0 g/hp-hr results.

The near-source short-term (using maximum hourly emissions) CALPUFF modeling of the Project emissions estimated the impacts of 3-hour and 24-hour SO_2, 8-hour CO, 24-hour PM_{10}, and 24-hour $PM_{2.5}$ concentrations. The near-source long-term (using maximum seasonal emissions) CALPUFF modeling of the Project emissions estimated the impacts of annual NO_2, SO_2, PM_{10}, and $PM_{2.5}$ concentrations. Additional CALPUFF model simulations were made for all permitted and reasonable foreseeable future development air basin sources since July 1, 1995 (excluding the Project). These post-95 sources impacts were added to the Project impact scenarios to provide the cumulative concentration impacts of all post-95 plus Project sources. The resultant near-source modeling Project impacts, post-95 sources impacts, and cumulative Project plus post-95 sources impacts were compared against the PSD Class II increments (Table 4-1b). The cumulative impact (Project plus post-95) were added to the maximum background concentrations (Table 4-2) for comparison against the NAAQS/WAAQS (Table 4-3). For the near-source modeling, CALPUFF was exercised using options consistent with its regulatory default near-source (ISC) mode.

Table 4-1a. PSD Increment Standards - Class I Areas

Pollutant	Averaging Period		
	Annual ($\mu g/m^3$)	**24-hour ($\mu g/m^3$)**	**3-hour ($\mu g/m^3$)**
Nitrogen dioxide	2.5	-	-
Sulfur oxides	2	5	25
Particulate Matter (less than 10 μm)	4	8	-

Table 4-1b. PSD Increment Standards - Class II Areas

Pollutant	Averaging Period		
	Annual ($\mu g/m^3$)	24-hour ($\mu g/m^3$)	3-hour ($\mu g/m^3$)
Nitrogen dioxide	25	-	-
Sulfur oxides	20	91	512
Particulate Matter (less than10 μm)	17	30	-

Table 4-2. Regional Baseline Ambient Concentrations ($\mu g/m^3$)

	1-hour	3-hour	8-hour	24-hour	Annual	Source
PM_{10}	---	---	---	18 ‡	8 ‡	Seedskadee National Wildlife Refuge
$PM_{2.5}$	---	---	---	10 ¥	5 ¥	Seedskadee National Wildlife Refuge/Solvay
NO_2	---	---	---	---	9 ¤	CCUCG
SO_2	---	132 §	---	43 §	9 §	Craven Creek
CO	3,500 *f*	---	1,500 *f*	---	---	Riley Ridge
O_3	---	---	130 †	---		CASTNet data from Pinedale

† Fourth-highest maximum daily 8-hour average, averaged over 3-year period (1992-1994); converted from ppb to $\mu g/m^3$ assuming standard temperature and pressure (25°C and 760 mmHg).

‡ Seedskadee (1995); for 24-hour averaging period, value represents 99th percentile.

¥ Seedskadee (1995); for 24-hour averaging period, value represents 98th percentile. Seasonal ratios of $PM_{10}/PM_{2.5}$ are taken from one year of data (1996-1997) gathered by Solvay.

¤ CCUCG June 1994 - May 1995; annual averaged value converted from ppb to $\mu g/m^3$ assuming standard temperature and pressure (25°C and 760 mmHg).

§ Gathered at the LaBarge Study Area, NW Pipeline Craven Creek (1982-1983). Values for 3-hour and 24-hour averaging periods represent maximum concentrations.

f Taken from representative data collected by WDEQ and commercial operators, and summarized in the Riley Ridge EIS (BLM, 1983). Values represent maximum concentrations.

Table 4-3. Wyoming Ambient Air Quality Standards

Pollutant	Averaging Period				
	Annual ($\mu g/m^3$)	24-hour ($\mu g/m^3$)	8-hour ($\mu g/m^3$)	3-hour ($\mu g/m^3$)	1-hour ($\mu g/m^3$)
Nitrogen dioxide	100	-	-	-	-
Sulfur oxides	60	260 †	-	1,300 †	-
Particulate Matter (less than10 μm)	50	150 †	-	-	-
Particulate Matter (less than2.5 μm)*	15	65 ‡	-	-	-
Ozone	-	-	160 †	-	-
Carbon monoxide	-	-	10,000 †	-	40,000 †

† Highest second-high

‡ Highest 98th percentile

* National Ambient Air Quality Standard

Near-Source CALPUFF Receptor Grid

For the CALPUFF near-source modeling, concentration estimates were obtained at receptors spaced 4-km apart overlaid on the Project area and covering the region out to 5-km from the project boundary (including the town of Pinedale). Additional receptors at 1-km resolution are specified around the three potential locations for the Project compressors. The near-source modeling receptor array is shown in Figure 4-2. The higher 1-km by 1-km receptor grids around the three potential locations for the compressor locations are clearly seen in Figure 4-2 for the most southerly compressor location C2, middle located compressor location C1 and most northerly receptor location C3.

Other CALPUFF Inputs

In addition to the meteorological and emissions inputs described in Chapters 2 and 3 and the receptor inputs described above, CALPUFF requires an input control file and an ozone data file as input. With the exception of using the ISC-default configuration for the near-source CALPUFF modeling and the IWAQM-recommended options for the far-field modeling and the different receptor grids, the CALPUFF inputs for the near-source and far-field modeling are nearly identical. One notable exception is that the near-source modeling used the CALPUFF "slug" configuration whereas the far-field modeling used the "puff" configuration. Thus, these CALPUFF inputs are described in detail in the far-field modeling presented later in this Chapter.

Estimated Impacts

The near-source estimated impacts of NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$ were obtained due to the Project development alone, post-95 permitted and reasonable future development sources alone, and cumulative Project plus post-95 sources. In addition, the total concentration impact

due to all existing sources (i.e., the Table 4-2 1995 baseline measurements) plus the cumulative impact due to the Project and post-95 sources were obtained.

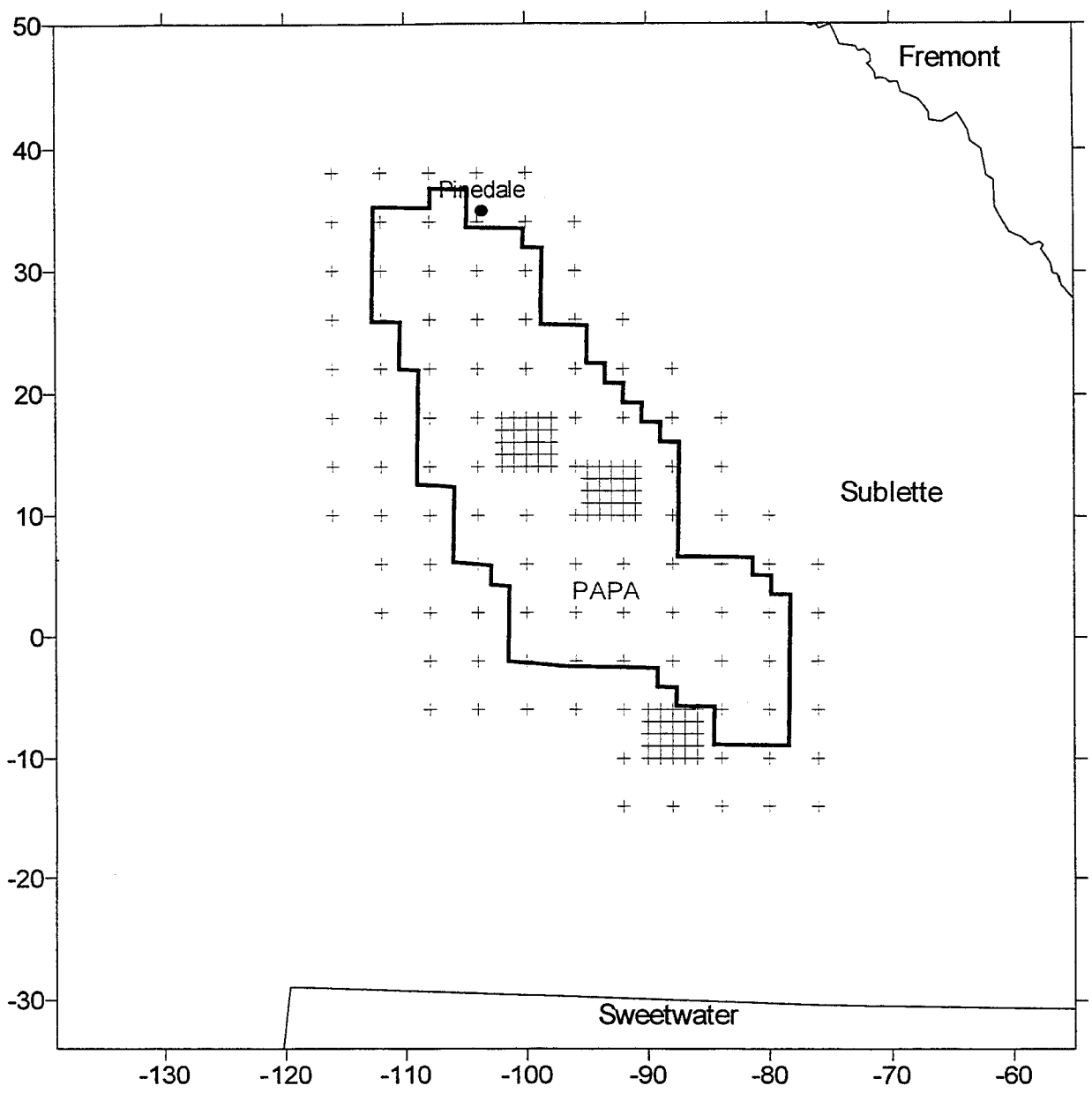


Figure 4-2. Near-source receptor grid at 4-km x 4-km resolution except around potential compressor station locations where a 1-km x 1-km receptor grid is used.

FAR-FIELD CALPUFF MODELING

The CALPUFF far-field modeling was run with the long-term (seasonal maximum) emissions estimates. The emissions used for the far-field modeling were the same as the long-term annual average emission scenario described in the near-source modeling discussed above. The far-field modeling included only receptors located at sensitive Class I and II areas in the domain. For the far-field modeling, CALPUFF was operated using the IWAQM-recommended default settings (as compared to the near-source CALPUFF modeling that used the ISC-default settings).

The far-field CALPUFF modeling estimated pollutant concentrations, visibility, and deposition at sensitive receptors in the mountain areas east and north of the project. The six Classes I and II areas of primary interest in this analysis were:

- Bridger Wilderness Area (Class I),
- Fitzpatrick Wilderness Area (Class I),
- Washakie Wilderness Area (Class I),
- Grand Teton National Park (Class I),
- Popo Agie Wilderness Area (Class II),
- Wind River Roadless Area (Class II).

To address NAAQS, WAAQS, and PSD increments in the Classes I and II areas, CALPUFF was used to estimate ambient SO_2, NO_2, PM_{10}, and $PM_{2.5}$ concentrations, sulfur and nitrogen deposition, and visibility impairment (light extinction by haze aerosols and NO_2). The time frame for the different PSD components varies greatly; deposition totals are analyzed on an annual basis whereas visibility requires a 24-hour assessment. The species modeled by CALPUFF for the far-field modeling were NO, NO_2, nitric acid, particulate nitrate, SO_2, sulfate, PM_{10}, and $PM_{2.5}$.

Ammonia is not directly modeled by CALPUFF, but ambient concentrations can be supplied as input for the internal equilibrium partitioning of total nitrate among nitric acid and aerosol nitrate. However, for the Pinedale Anticline Project application of CALPUFF, the sulfate/nitrate/ammonia equilibrium calculation was performed on the hourly CALPUFF model outputs using a modified version of the Mount Zirkel Visibility Study (MZVS) CALPUFF post-processor, which is described in more detail below. This approach allows the evaluation of several alternatives to the Project development without having to re-run CALPUFF for all of the sources each time. This approach also allows the assessment of the impacts due to the Project sources alone, post-95 sources alone, cumulative impacts due to post-95 sources plus the Project sources, as well as the total concentrations due to all sources (existing 1995 baseline plus the cumulative impacts). The model outputs hourly concentrations for the entire 1995-year from which 3-hour, 8-hour, 24-hour, and annual mean concentration estimates are constructed. Deposition was output daily and accumulated throughout the year to obtain an annual total deposition flux.

CALPUFF Modeling Domain

The CALPUFF computational grid was a subset of the CALMET domain consisting of a modeling domain that coincides with the Wyoming border on the south and west and the CALMET domain boundaries on the north and east (see Figure 4-1). The CALMET/CALPUFF modeling domains are based on a Lambert Conformal Projection (LCP) using a 4-km resolution. The LCP projection is defined with a longitude/latitude centroid at (-108.55°, 42.55°) and first and second standard latitude parallels at 30° and 60° (to match the MM5 data used in the CALMET modeling, see Chapter 2).

Far-Field Receptor Locations

For the CALPUFF Pinedale Anticline Project far-field modeling, receptors were placed along the boundaries of the sensitive receptor areas at a spacing designed to sample plume centerline maximum concentrations. However, care was also taken not to specify too many receptors that obtain much redundant information at the expense of excessive CALPUFF run times. Thus, for the sensitive receptor area boundaries within 50-km of the centroid of the Project area, receptors were placed approximately 1-km apart. For the sensitive receptor area boundaries located within 50-km to 80-km of the centroid of the Project area, receptors were placed approximately 4-km apart from each other. For the sensitive receptor areas located greater than80-km from the centroid of the Project area, receptors were placed 8-km apart from each other. The locations of the far-field modeling CALPUFF receptors and their relationship to the Project area are shown in Figure 4-3. The receptor pattern was selected to provide the most conservative estimates of ambient concentration and visibility impacts at the sensitive areas. Additional receptors were placed at sensitive lakes in the region. This resulted in the following groups of receptors (see Figure 4-3):

Wind River Range Receptors: Discrete receptors were placed along the Bridger Wilderness Area (Class I), Fitzpatrick Wilderness (Class I), Popo Agie Wilderness Area (Class II), and Wind River Roadless Area (Class II) boundaries. The receptors are approximately one kilometer spacing for boundaries closest (less than 50-km) to the Project area and 4-km spacing for the more distant (50-80-km) boundary segments from the Project area.

Grand Teton NP Receptors: Discrete receptors were placed in the Grand Teton National Park (Class I) along the southern boundaries spaced 8-km apart.

Washakie Wilderness Area Receptors: Discrete receptors were placed at the southern boundary of the Washakie Wilderness Area (Class I) spaced 8-km apart. (These impacts were also used as representative of impacts in the south end of Teton Wilderness Area, Class I).

Sensitive Lake Receptors: Discrete receptors were placed at the following sensitive lakes: Deep, Ross, Lower Saddlebag, Hobbs, and Black Joe.

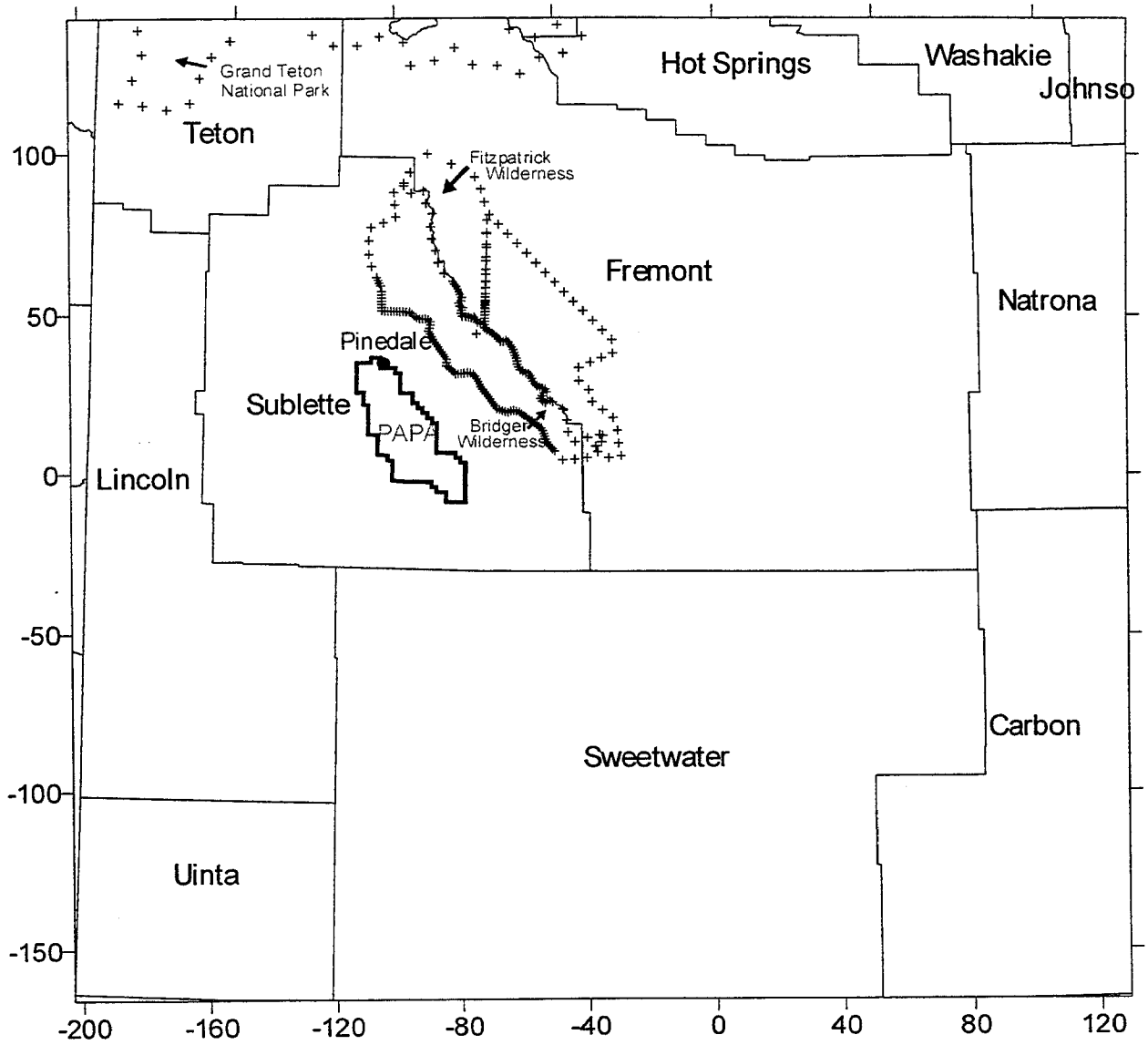


Figure 4-3. CALPUFF far-field modeling receptor locations along sensitive area boundaries spaced 1-km (less than 50-km from the Project), 4-km (50-80-km from the Project), and 8-km (greater than 80-km from the Project) apart.

Other CALPUFF Inputs

In addition to the meteorological and emissions input data files described in Chapters 2 and 3 and the receptor inputs described above, CALPUFF also requires a user input control file and an ozone data input file. There are also several optional files that were not used in the Pinedale Anticline Project CALPUFF application (e.g., user-specified deposition velocity, chemical conversion rates, turbulence data, and isolated hill files). For the far-field modeling, CALPUFF was operated in a mode recommended by the IWAQM. The CALPUFF concentration estimates were post-processed using observed 1995 baseline air quality data to perform the equilibrium calculation between sulfate, nitrate, and ammonia to obtain the estimated particulate sulfate, nitrate, and ammonium.

The Interagency Workgroup for Air Quality Modeling (IWAQM) has developed a set of defaults for the CALPUFF model for performing PSD-type increment and visibility modeling. These recommendations are based on earlier versions of CALPUFF and IWAQM has not formulated any recommendations for some of the new features in CALPUFF5. For the CALPUFF far-field modeling, the IWAQM defaults were used where consistent with the current CALPUFF5. Thus, the default dry and wet deposition algorithms were used.

Exhibit 4-1 (presented at the end of this Chapter) presents an example CALPUFF input control file used in the Pinedale Anticline Project EIS modeling. This example is for far-field modeling of emissions from the Project compressor location C1. The following CALPUFF options were specified:

- Gaussian near-field distribution
- Transitional plume rise
- Stack tip downwash
- PG dispersion coefficients (rural areas), McElroy-Pooler coefficients (urban areas)
- Transition of horizontal dispersion to time-dependent (Heffter) growth rates
- Building downwash effects (ISC3 techniques)
- Wet deposition, dry deposition, and chemical transformation were considered

CALPUFF5 has implemented a new (RIVAD/ARM3) empirical chemical transformation algorithm taken from the ARM3 model (Morris et al., 1988). The ARM3 chemical transformation algorithm contains a separate treatment of NO and NO_2, rather than lumping them together as NO_x as in the old algorithm (MESOPUFF-II). IWAQM has not evaluated the new algorithm so has not formulated a recommendation. Given the improved ability to separately treat NO_2 in the new algorithm and the more appropriate response of the new algorithm to changes in environmental parameters than the old (MESOPUFF-II) algorithm, the new algorithm was used in the Pinedale Anticline Project EIS CALPUFF modeling.

CALPUFF Air Quality Inputs

Air quality observations are used to define the ozone input file to CALPUFF for use in the empirical chemical transformation algorithm. Ozone data collected at the Pinedale CASTNet NDDN site were the primary source for the CALPUFF hourly ozone inputs. However, these data were missing for October, November, and December 1995. Thus, for the last three months of 1995, when the Pinedale NDDN ozone data were missing, the Centennial ozone data were used as they appeared to be more representative of the Pinedale area and more conservative (i.e., slightly higher) than the other ozone data sources.

Ambient measurements of SO_2, NO_2, nitrate, sulfate, ammonia, $PM_{2.5}$, and PM_{10} were used to define a 1995 baseline air quality. Note that in addition to the background ozone inputs used in the CALPUFF chemical conversion module, there are three other uses of the 1995 measured baseline air quality data:

Chemical Background: Background total ammonia, total sulfate, and total nitrate are needed to combine with the CALPUFF-estimated total sulfate and total nitrate to perform the temperature and relative humidity-dependant equilibrium calculation to estimate particulate ammonium nitrate;

NAAQS Background: For criteria pollutants, a 1995 background concentration is needed to add to the CALPUFF-estimated pollutant concentrations for comparisons with the NAAQS and WAAQS (see Table 4-2); and

Visibility Background: For visibility calculations, a background extinction is needed to estimate whether the Project, post-95 sources, and cumulative visibility impacts exceed Limit of Acceptable Change (LAC) thresholds.

The background concentration values listed in Table 4-2 were used for the NAAQS Background concentrations listed above. These values represent maximum measured concentrations for each criteria pollutant in the region, thus they are conservative for most receptor areas.

The Bridger Wilderness Area IMPROVE measurement program site, that measured sulfate, nitrate, and other speciated PM, provides the most complete and best characterization of baseline PM conditions in the domain. The Bridger IMPROVE site reconstructed mass data were used to characterize the Chemical Background and Visibility Background for all sites. However, different procedures were used to obtain the Chemical and Visibility Backgrounds from the IMPROVE data. Monthly average Bridger IMPROVE PM species for 1995 were used to define a monthly-specific Chemical background. In addition to the sulfate, nitrate, and reconstructed ammonium PM mass concentrations from the Bridger IMPROVE data, the Chemical Background also requires estimates of background gaseous free ammonia and nitric acid concentrations in order to properly perform the sulfate/nitrate/ammonium equilibrium calculations. There are very few free ammonia or nitric acid measurements in the area. The Mount Zirkel Visibility Study (MZVS) measured free ammonia and nitric acid at three sites approximately 220-320-km to the southeast of the Project area during 1995. Based on an analysis of the MZVS data base, values for background gaseous ammonia and nitric acid of

1.0 and 0.2 ppb were selected. These values would provide conservative (overestimates) impacts of the PM and visibility impacts of the Project and post-95 sources.

The Visibility Background was defined using a slightly modified version of the IWAQM/FLAG recommendations. IWAQM recommends using a Visibility Background based on the mean of the 20 percent cleanest days from a long-term (approximately 10 year) record. The FLAG Visibility Subgroup report has listed the mean of the 20 percent cleanest days of the Bridger IMPROVE reconstructed mass data from 1987-1997 for use as a Visibility Background. Since we were modeling the contributions of the emissions permitted since July 1, 1995, then there was a potential for "double counting" sources during the 1995-1997 time period (i.e., the contributions due to recently permitted sources in operation during July 1995 to 1997 were included in both the CALPUFF estimated post-95 air quality impacts as well as possibly the 1987-1997 baseline Visibility Background). Thus, the IWAQM recommended approach has been modified slightly to eliminate the 2-year overlap. Thus, the Visibility Background for the Pinedale Anticline Project EIS analysis was based on the mean of the 20 percent cleanest days from the Bridger IMPROVE reconstructed mass data from 1987 to June 30, 1995. These two Visibility Backgrounds are compared in Tables 4-4a and 4-4b.

CALPUFF Post-processing Procedures

NO_x was a major component of the emissions from the Project and other gas development activities in southwestern Wyoming. CALPUFF simulated the oxidation of NO_x to nitrate. In addition, CALPUFF has an internal algorithm that calculates the equilibrium between sulfate, nitrate, and ammonia to determine how much of the converted NO_x is particulate nitrate and how much is gaseous nitric acid. The equilibrium relationship depends on temperature, humidity, and the total amount of sulfate, particulate nitrate plus nitric acid, and ammonia plus ammonium present from all sources. These calculations must be made accounting for sources present in 1995 (i.e., the 1995 Chemical Background baseline air quality measurements) and contributions due to emissions from the post-95 sources and emissions from the Project sources. Thus, the internal CALPUFF equilibrium algorithm is inappropriate for use in this modeling analysis of the emissions (post-95) because it neglects the contributions of sources that existed in 1995 that are included in the Chemical Background concentrations.

A modified version of the MZVS CALPUFF post-processor was used to process the CALPUFF output with the 1995 baseline Chemical Background air quality data to estimate particulate nitrate and obtain the Project and post-95 sources separate and cumulative source contributions to PM and extinction. The nitrate concentration impacts (particulate nitrate plus nitric acid) estimated by CALPUFF (post-95 and the Project sources) were added to the measured nitrate Chemical Background (IMPROVE particulate nitrate plus 0.2 ppb MZVS nitric acid) concentrations (representing contributions due to 1995 existing sources) to obtain the total nitrate due to all sources. Similarly, the CALPUFF-estimated sulfate cumulative concentrations were added to the measured sulfate Chemical Background concentration to obtain sulfate due to all sources. Total ammonia due to all sources were obtained by adding the IMPROVE Chemical Background particulate ammonium with the MZVS Chemical Background gaseous ammonia (1.0 ppb). The temperature- and humidity-dependent equilibrium relationship between nitrate, sulfate, and ammonia were calculated to obtain

hourly ammonium sulfate, ammonium nitrate, ammonia, and nitric acid concentrations due to all sources (existing 1995, post-95, and the Project):

$$NH_4NO_3\ (pm) \Leftrightarrow HNO_3\ (g) + NH_3\ (g)$$

The equilibrium calculation was made on an hourly basis to account for the diurnal variations in temperature and relative humidity. The ammonium nitrate contribution due to the post-95 and the Project sources was based on their relative fraction of their particulate nitrate plus nitric acid concentrations to the total particulate nitrate plus nitric acid concentrations due to all sources (1995 baseline, post-95, and the Project).

The hourly sulfate, nitrate, and ammonium from the equilibrium calculations and the CALPUFF-estimated and background NO_2 and fine and coarser particulate concentrations were averaged to obtain 24-hour average concentrations for the visibility calculations.

Calculation of Extinction, Deciview, and Visual Range

A slightly modified version of the IWAQM recommended approach for defining Baseline Visibility Background was used to assess the visibility impacts in the Pinedale Anticline Project EIS. The IWAQM recommended approach is to calculate extinction due to the source concentrations using seasonal relative humidity (RH) adjustments and compare to a Seasonal background visibility based on the average of the 20 percent cleanest days from 1987-1997. As discussed above, to avoid double counting sources that have been permitted since July 1, 1995, the Visibility Background for the Pinedale Anticline Project EIS was based on the mean of the 20 percent cleanest days from 1987-June 30, 1995 period. Table 4-4a lists the recommended Visibility Background based on the Bridger Wilderness IMPROVE data from the 1987-1997 period, where as the Visibility Background used in the Pinedale Anticline Project EIS based on the same data for the 1987-June 30, 1995 period are shown in Table 4-4b. The IWAQM recommendations also do not include the effects of absorption by NO_2 in their visibility assessment. Due to the proximity of the Project to several of the sensitive Class I and Class II receptor areas, NO_2 may be an important contributor to the incremental extinction budget. Thus, it was included in the extinction budget in the post-processing of the Pinedale Anticline Project EIS CALPUFF modeling.

Table 4-4a. IWAQM-recommended current visibility conditions (mean of the best 20% from 1987-1997) In the Bridger Wilderness Area based on IMPROVE monitoring data (Source: FLAG, 12/10/98)

Season	Components of "Dry" Extinction (Mm^{-1})			Particle B_{ext} w/f(RH) (Mm^{-1})	Current Visibility (Mm^{-1})
	Nonhygroscopic	Hygroscopic	Nominal Rayleigh		
Annual	3.02	1.13	10	5.46	15.46
Autumn	3.63	1.19	10	6.37	16.37
Spring	3.51	1.77	10	7.56	17.56
Summer	6.08	1.79	10	9.05	19.05
Winter	2.68	0.74	10	4.41	14.41

Table 4-4b. Visibility Background used in the Pinedale Anticline Project EIS (mean of the best 20% from 1987-June 30, 1995) in the Bridger Wilderness Area based on IMPROVE monitoring data (Source: USDA Forest Service/Copeland, 1999)

	Modeling Background Parameters for Bridger Wilderness 3/1/1988 - 6/30/95			
	Mean of Cleanest 20%		Mean	Mean
Season	Dry Hygroscopic Extinction (Mm^{-1})	Non-Hygroscopic Extinction (Mm^{-1})	f(RH)	RH (%)
Spring	1.92	3.96	2.30	76
Summer	1.86	6.32	1.56	63
Autumn	1.23	4.26	2.21	75
Winter	0.72	3.11	2.37	77

The 24-hour cumulative total extinction (b_{source}) is calculated from the individual CALPUFF-estimated 24-hour particulate and NO_2 extinction as follows:

$$b_{source} = b_{SO4} + b_{NO3} + b_{fine} + b_{coarse} + b_{NO2}$$

Extinction due to each of the particle scattering and NO_2 absorption components is obtained by applying a scattering/absorption efficiency to the concentration ($\mu g/m^3$ for particulate and ppb for gaseous species) as follows:

$$b_{SO4} = 3\,[(NH_4)_2SO_4]f(RH)$$

$$b_{NO3} = 3\,[NH_4NO_3]f(RH)$$

$$b_{fine} = A\,[PM_{2.5}]$$

$$b_{coarse} = 0.6\,[PM_{10} - PM_{2.5}]$$

$$b_{NO2} = 0.17\,[NO_2]$$

Here, as recommended by IWAQM, the seasonal f(RH) values were used (see Table 4-4b). The constant A for the fine particulate extinction component was based on the relative contributions of dust/soil (A=1), EC (A=10), and OC (A=4) to the fine particulate emissions. Based on a review of the Project emissions, we found a majority of the primary $PM_{2.5}$ emissions were from construction sources (i.e., dust/soil) and an average value for A of 1.2 was estimated (A=1.2).

The estimation of the baseline extinction levels will use the seasonal data for clean days from the Bridger Wilderness Area IMPROVE site with baseline extinction obtained as follows:

$$b_{base} = b_{NS}f(RH) + b_{dry} + b_{ray}$$

Where b_{NS} is the sulfate-nitrate Hygroscopic component from Table 4-4b for the appropriate season, b_{dry} and b_{ray} are the respectively, nonhygroscopic and Rayleigh scattering components from Table 4-4b, and f(RH) is the seasonal average f(RH) value for the day under study (Table 4-4b).

For each day the percent change in extinction due to the Project, post-95 (P1995) sources, and combined Project+post-95 sources to the baseline extinction were calculated as follows.

$$\Delta b_{Project} = 100 \times [b_{Project} / b_{base}]$$

$$\Delta b_{p1995} = 100 \times [b_{p1995} / b_{base}]$$

$$\Delta b_{p\ 1995\ +\ Project} = 100 \times [b_{p1995\ +\ Project} / b_{base}]$$

Visual Range is easily calculated from extinction from the formula:

$$VR(km) = 3912 / b_{ext}\ (Mm^{-1})$$

Finally deciview (dv) is also readily calculated from the extinction as follows:

$$dv = 10\ ln_e(b_{ext} / 10\ Mm^{-1})$$

The deciview due to the Project and post-95 sources were then calculated as follows:

$$\Delta dv_{Project} = dv_{base\ +\ p1995\ +\ Project} - dv_{base\ +\ p1995} = 100 \times ln_e\ [1 + (b_{Project} / b_{base})]$$

$$\Delta dv_{p1995} = dv_{base\ +\ p1995} - dv_{base} = 100 \times ln_e\ [1 + (b_{p1995} / b_{base})]$$

$$\Delta dv_{p1995+\ Project} = dv_{base\ +\ p1995\ +\ Project} - dv_{base} = 100 \times ln_e\ [1 + (b_{p1995\ +\ Project} / b_{base})]$$

CALPUFF Far-Field Modeling Estimated Impacts

Three types of air quality and air quality related value (AQRVs) impacts were assessed using the CALPUFF far-field modeling: (1) comparison with applicable NAAQS and WAAQS standards and PSD Classes I and II increments; (2) incremental visibility degradation and comparison with the 0.5 and 1.0 deciview change (Δdv) Limit of Acceptable Change (LAC) thresholds; and (3) annual deposition fluxes on sensitive lake receptors

Annual average NO_2, SO_2, PM_{10}, and $PM_{2.5}$ due to the Projects, post-95, and cumulative sources were added to the 1995 baseline NAAQS background ambient air quality and compared with the appropriate NAAQS and WAAQS. The annual average contribution of NO_2, SO_2, and PM_{10} due to the Project, post-95 and cumulative Project plus post-95 sources

were compared with PSD Classes I and II increments. The Project, post-95, and cumulative (Project + post-95) concentration contributions and total (cumulative plus background) 24-hour SO_2, PM_{10}, and $PM_{2.5}$ impacts were compared against applicable NAAQS and WAAQS standards (Table 4-3). 24-hour SO_2 and PM_{10} contributions due to the Project sources alone were compared to the PSD Class I and II increments (Tables 4-1a and 4-1b).

Similarly, 24-hour SO_2, PM_{10}, and $PM_{2.5}$ and 3-hour SO_2 contributions and total concentrations were compared against the applicable NAAQS, WAAQS. Impacts from the Project sources alone were compared with the PSD Classes I and II increment standards (the 1-hour and 8-hour CO NAAQS and WAAQS standards are treated in the near-source modeling).

Visibility Impacts

Estimated 24-hour extinction due to the Project contribution, post-95 sources contribution, cumulative Project plus post-95 sources contributions were processed to obtain visibility impairment in terms of changes in extinction and deciview (Δdv) from the baseline Visibility Background (i.e., mean of the 20% cleanest days). The frequency of occurrence of impacts from the cumulative analyses of deciviews exceeding 0.5 and 1.0 Δdv and extinction exceeding 5 and 10 percent of the baseline Visibility Background was tabulated for each sensitive receptor area and each Project Alternative.

Two thresholds of visibility change are reported here, days with greater than 1.0 deciview change, and days with greater than 0.5 deciview change. The USDA Forest Service uses the 0.5 deciview as a Limit of Acceptable Change (LAC) threshold in order to protect visibility in sensitive areas to visibility changes. The 1.0 deciview threshold is used in the Regional Haze Regulations as a small but possible precipitous change in visibility.

Acid Deposition Impact Assessment

Annual wet, dry, and total (wet + dry) deposition fluxes of all sulfur and nitrogen species at the five sensitive lake receptors predicted by CALPUFF for the Project development alone and cumulative sources were tabulated. For the five sensitive lake receptor sites, the annual deposition fluxes were used to estimate the potential change in acid neutralizing capacity (ANC) following the procedures used in Fox et. al., (1989). The results were compared with the USDA Forest Service LAC threshold change of 10%. Sulfur deposition is obtained by combining the CALPUFF-estimated wet and dry deposition of SO_2 and sulfate. Total nitrogen (N) deposition is obtained by summing the CALPUFF-estimated wet and dry deposition of NO_2, NO_3, and HNO_3, as well as assuming 2 additional N for each deposited SO_4 and one additional N for each deposited NO_3 due to ammonia.

Table 4-5 summarizes the current ANC values for the sensitive lakes analyzed in the Pinedale Anticline Project EIS acid deposition assessment. The 10% most sensitive ANC values for each lake is used as a background ANC in the assessment of the 10% change LAC threshold.

Table 4-5. Bridger Wilderness Area Monitored Lake Acid Neutralizing Capacity (ANC) in μeq/l.

Lake	Number of Observations	10% Most Sensitive	Mean	Maximum	Minimum
Black Joe 1984-1998	34	55.2	79.5	122.8	45.8
Deep 1984-1998	35	49	78.9	113.6	40
Hobbs 1984-1998	38	63	114.7	250.1	57
Ross 1985-1998	37	55.8	64.4	78.0	51
Lower Saddlebag 1986-1998	31	58.3	69.0	84	28.4

The Fox acid deposition screening method calculates a change in pH (Δ pH) using the following formulas:

$$\Delta pH = \ln_e (A) - \ln_e \{A - [(H_S+H_N+H_c)/d/1000]\}$$

$$\% \text{ Alkalinity Change} = \{(H_S+H_N+H_c)/d/1000\}/[A] \times 100$$

Where:

A = Baseline Alkalinity (eq/l) = ANC/1000000
d = Annual ppt (m)
H_S = D_S/(10 x R_S x 32) for SO_2 (eq/m^2)
H_N = D_N/(10 x R_N x 46) for NO_2 (eq/m^2)
H_C = D_C/(10 x R_C x 60) for COS (= 0 in Pinedale Anticline Project EIS)
D_S = sulfur deposition (as SO_2).(kg/ha)
D_N = nitrogen deposition (as NO_2).(kg/ha)
D_C = sulfur deposition from COS (= 0 in Pinedale Anticline Project EIS)
R_S = sulfur/total weight of SO_2 (32/64 = 0.5)
R_N = nitrogen/total weight of NO_2 (14/64 = 0.3)
R_C = sulfur/total weight of COS (32/60 = 0.5)

Modeling of NOx Emission Reductions at the Naughton Generating Station

One of the potential operators of the Pinedale Anticline Project, Ultra Petroleum, negotiated with PacifiCorp to partly fund the purchase of low-NOx burners for Unit 3 of the Naughton Electrical Generating Station. This mechanism for decreasing NOx emissions in the Green River basin is not useful for permitting of the Project sources under current Wyoming regulations. However, it does represent a decrease in NOx emissions and this decrease represents a potential benefit to the basin. PacifiCorp expects the actual control benefit from the Unit 3 low-NOx burners to be about 2,000 tons per year, or about 33 percent of present NOx emissions from that unit.

No changes in stack physical parameters (flow rate, temperature and stack diameter) are expected to result from addition of the low-NO_x burners. For purposes of indicating the relative value of this emissions decrease to the regional air basin, the air quality and visibility benefits due to this emission decrease were compared with any expected increase from the Project and post-95 emissions in the basin.

Two separate CALPUFF model runs were made to evaluate the benefit of the Naughton Unit 3 NOx emission control in the sensitive Class I and II areas and the area local to Naughton. The first run was performed with Naughton Units 1, 2, and 3 NOx, SO_2, and PM_{10} emissions at the 1995 actual (baseline) emissions levels. These existing emissions for Naughton Units 1, 2, and 3 are, respectively: 3491, 4083, and 6033 tons per year of NOx; 6358, 7945, and 3980 tons per year of SO_2; and 339, 747, and 694 tons per year of PM_{10}. The second CALPUFF simulation uses the same emissions, only reducing the Naughton Unit 3 NOx emissions from 6033 to 4033 tons per year. These model runs used the same CALPUFF setup, meteorology and physical parameters as used for evaluation of the far-field effects of the Project sources. Receptors were placed in each of the sensitive receptor areas (i.e., the far-field receptor network, see Figure 4-3) as well as on a 5-km grid in the region within a 30-km radius of Naughton.

The impacts of the Naughton NOx emissions reductions were evaluated two ways. First, the reductions in extinction due the Naughton NOx reductions in the sensitive receptor areas that occurred concurrently (i.e., at the same time and location) with any visibility degradation due to the cumulative (Project+post-95) impacts were evaluated. Second, the number of days the 0.5 Δdv and 1.0 Δdv LAC thresholds are reduced due to the Naughton NOx emissions reductions are compared with the number of days the LAC thresholds are exceeded due to the cumulative (Project+post-95) sources impacts independent on whether they occurred on the same day and at the same receptor.

Exhibit 4-1. Example CALPUFF input control file for the Pinedale Anticline Project CALPUFF modeling of compressor location number 1 operating at 1.0 g/hp-hr NO_x emissions.

```
CALPUFF Input File
January, 1995
Far-Field Modeling of Project Compressor #1(mid) Emissions
---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input !METDAT=/disk13/Project/calmet/outputs/calmet.95jan.dat!
    or
ISCMET.DAT    input    * ISCDAT =             *
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB= /disk11/Project/calpuff/outputs/restart.far.Projectc1.95pre.dat
*
------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =
/disk11/Project/calpuff/outputs/calpuff.far.Projectc1.95jan.lst!
CONC.DAT      output   ! CONDAT = /disk11/Project/calpuff/outputs/conc.far.Projectc1.95jan.dat!
DFLX.DAT      output   ! DFDAT  = /disk11/Project/calpuff/outputs/dflx.far.Projectc1.95jan.dat!
WFLX.DAT      output   ! WFDAT  = /disk11/Project/calpuff/outputs/wflx.far.Projectc1.95jan.dat!

VISB.DAT      output   * VISDAT =  *
RESTARTE.DAT  output   ! RSTARTE= /disk11/Project/calpuff/outputs/restart.far.Projectc1.95jan.dat
!
------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEM.DAT     input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    ! OZDAT  = /disk11/Project/calpuff/inputs/ozone/ozone.jan !
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
HILL.DAT      input    * HILDAT=              *
HILLRCT.DAT   input    * RCTDAT=              *
DEBUG.DAT     output   * DEBUG =              *
------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = T !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 70 characters in length

!END!
------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file(s)  (METRUN)   Default: 0       ! METRUN =   1  !

         METRUN = 0 - Run period explicitly defined below
```

```
        METRUN = 1 - Run all periods in met. file(s)

     Starting date:   Year (IBYR) -- No default       ! IBYR =  95  !
     (used only if   Month (IBMO) -- No default       ! IBMO =  01  !
      METRUN = 0)      Day (IBDY) -- No default       ! IBDY =  01  !
                      Hour (IBHR) -- No default       ! IBHR =  07  !

     Length of run (hours) (IRLG) -- No default       ! IRLG =  24  !

     Number of chemical species (NSPEC)
                                  Default: 5          ! NSPEC = 8   !

     Number of chemical species
     to be emitted  (NSE)         Default: 3          ! NSE =  8    !

     Flag to stop run after
     SETUP phase (ITEST)          Default: 2          ! ITEST =  2   !
     (Used to allow checking
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP


     Restart Configuration:

        Control flag (MRESTART)   Default: 0          ! MRESTART = 2 !
           0 = Do no read or write a restart file
           1 = Read a restart file at the beginning of
               the run
           2 = Write a restart file during run
           3 = Read a restart file at beginning of run
               and write a restart file during run

        Number of periods in Restart
        output cycle (NRESPD)     Default: 0          ! NRESPD = 0   !
           0 = File written only at last period

     Meteorological Data Format (METFM)
                                  Default: 1          ! METFM =  1   !

           METFM = 1 - CALMET binary file (CALMET.MET)
           METFM = 2 - ISC ASCII file (ISCMET.MET)
           METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
           METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)

     Averaging Time (minutes) (AVET)
                                  Default: 60.0       ! AVET = 60. !
     PG sigma-y is adjusted by the equation
     (AVET/60.0)**0.2


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)              Default: 1      ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                         Default: 1      ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment
```

```
Subgrid-scale complex terrain
flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
   0 = not modeled
   1 = modeled

Near-field puffs modeled as
elongated 0 (MSLUG)                   Default: 0     ! MSLUG =  0   !
   0 = no
   1 = yes (slug model used)

Transitional plume rise modeled ?
(MTRANS)                              Default: 1     ! MTRANS =  1   !
   0 = no  (i.e., final rise only)
   1 = yes (i.e., transitional rise computed)

Stack tip downwash? (MTIP)            Default: 1     ! MTIP =  1  !
   0 = no  (i.e., no stack tip downwash)
   1 = yes (i.e., use stack tip downwash)

Vertical wind shear modeled above
stack top? (MSHEAR)                   Default: 0     ! MSHEAR =  0  !
   0 = no  (i.e., vertical wind shear not modeled)
   1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT)      Default: 0     ! MSPLIT =  1  !
   0 = no (i.e., puffs not split)
   1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM)       Default: 1     ! MCHEM =  3   !
   0 = chemical transformation not
       modeled
   1 = transformation rates computed
       internally (MESOPUFF II scheme)
   2 = user-specified transformation
       rates used
   3 = transformation rates computed
       internally (RIVAD/ARM3 scheme)

Wet removal modeled ? (MWET)          Default: 1     ! MWET =  1   !
   0 = no
   1 = yes

Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  1   !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)

Method used to compute dispersion
coefficients (MDISP)                  Default: 3     ! MDISP =  3   !

   1 = dispersion coefficients computed from measured values
       of turbulence, sigma v, sigma w
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.
   5 = CTDM sigmas used for stable and neutral conditions.
       For unstable conditions, sigmas are computed as in
       MDISP = 3, described above.  MDISP = 5 assumes that
       measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)         Default: 3     ! MTURBVW =  3  !
   1 = use sigma-v or sigma-theta measurements
       from PROFILE.DAT to compute sigma-y
       (valid for METFM = 1, 2, 3, 4)
   2 = use sigma-w measurements
       from PROFILE.DAT to compute sigma-z
       (valid for METFM = 1, 2, 3, 4)
   3 = use both sigma-(v/theta) and sigma-w
```

```
            from PROFILE.DAT to compute sigma-y and sigma-z
            (valid for METFM = 1, 2, 3, 4)
         4 = use sigma-theta measurements
            from PLMMET.DAT to compute sigma-y
            (valid only if METFM = 3)

      Back-up method used to compute dispersion
      when measured turbulence data are
      missing (MDISP2)                        Default: 3     ! MDISP2 =  3  !
      (used only if MDISP = 1 or 5)
         2 = dispersion coefficients from internally calculated
            sigma v, sigma w using micrometeorological variables
            (u*, w*, L, etc.)
         3 = PG dispersion coefficients for RURAL areas (computed using
            the ISCST multi-segment approximation) and MP coefficients in
            urban areas
         4 = same as 3 except PG coefficients computed using
            the MESOPUFF II eqns.

      PG sigma-y,z adj. for roughness?        Default: 0     ! MROUGH =  0  !
      (MROUGH)
         0 = no
         1 = yes

      Partial plume penetration of            Default: 0     ! MPARTL =  1  !
      elevated inversion?
      (MPARTL)
         0 = no
         1 = yes

      Strength of temperature inversion       Default: 0     ! MTINV =  0  !
      provided in PROFILE.DAT extended records?
      (MTINV)
         0 = no (computed from measured/default gradients)
         1 = yes

      PDF used for dispersion under convective conditions?
                                              Default: 0     ! MPDF =  0  !
      (MPDF)
         0 = no
         1 = yes

      Test options specified to see if
      they conform to regulatory
      values? (MREG)                          Default: 0     ! MREG =  0  !

         0 = NO checks are made
         1 = Technical options must conform to USEPA values for
            short-range modeling (e.g. ISC-type applications)
         2 = Technical options must conform to USEPA values for
            long-range modeling (e.g. visibility-type applications)
         3 = Other constraints


!END!


--------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =          SO2 !          !END!
! CSPEC =          SO4 !          !END!
! CSPEC =           NO !          !END!
! CSPEC =          NO2 !          !END!
! CSPEC =         HNO3 !          !END!
! CSPEC =          NO3 !          !END!
! CSPEC =        PM2.5 !          !END!
```

```
! CSPEC =          PM10 !          !END!

                                                                  Dry                    OUTPUT GROUP
    SPECIES                    MODELED          EMITTED       DEPOSITED                  NUMBER
     NAME                  (0=NO, 1=YES)    (0=NO, 1=YES)    (0=NO,                   (0=NONE,
   (Limit: 12                                                   1=COMPUTED-GAS           1=1st CGRUP,
    Characters                                                  2=COMPUTED-PARTICLE      2=2nd CGRUP,
    in length)                                                  3=USER-SPECIFIED)        3= etc.)

!          SO2  =          1,               1,               1,                       0   !
!          SO4  =          1,               1,               2,                       0   !
!           NO  =          1,               1,               1,                       0   !
!          NO2  =          1,               1,               1,                       0   !
!         HNO3  =          1,               1,               1,                       0   !
!          NO3  =          1,               1,               2,                       0   !
!        PM2.5  =          1,               1,               2,                       0   !
!         PM10  =          1,               1,               2,                       0   !

!END!

-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by.treating each size-range as a separate species.
  Order must be consistent with 3(a) above.


--------------------------------------------------------------------------------


INPUT GROUP: 4 -- Grid control parameters
--------------


METEOROLOGICAL grid:

            No. X grid cells (NX)      No default     ! NX = 116  !
            No. Y grid cells (NY)      No default     ! NY = 100  !
         No. vertical layers (NZ)      No default     ! NZ =  9   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = 4. !
                                       Units: km

                Cell face heights
                    (ZFACE(nz+1))      No defaults
                                       Units: m
   ! ZFACE = 0.,20.,80.,160.,300.,600.,1000.,1500.,2200.,3000.  !

            Reference Coordinates
           of SOUTHWEST corner of
                grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = -335. !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = -258. !
                                      Units: km

                UTM zone (IUTMZN)      No default     ! IUTMZN =   12  !

   Reference coordinates of CENTER
        of the domain (used in the
    calculation of solar elevation
                        angles)

            Latitude  (deg.) (XLAT)    No default     ! XLAT  = 42.68    !
           Longitude (deg.) (XLONG)    No default     ! XLONG = 109.815  !
             Time zone        (XTZ)    No default     ! XTZ   = 7  !
       (PST=8, MST=7, CST=6, EST=5)
```

```
Computational grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP = 34   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP = 24   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP = 116  !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP = 100   !
                  (1 <= JECOMP <= NY)


SAMPLING GRID (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)         Default: T     ! LSAMP = F !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)      No default     ! IBSAMP =  0   !
          (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)      No default     ! JBSAMP =  0   !
          (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)      No default     ! IESAMP =  0   !
          (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)      No default     ! JESAMP =  0   !
          (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                      Default: 1     ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!

--------------------------------------------------------------------------------


INPUT GROUP: 5 -- Output Options
--------------

                                        *                          *
     FILE                          DEFAULT VALUE                VALUE THIS RUN
     ----                          -------------                --------------

   Concentrations (ICON)                 1                     !  ICON =  1   !
   Dry Fluxes (IDRY)                     1                     !  IDRY =  1   !
   Wet Fluxes (IWET)                     1                     !  IWET =  1   !
   Relative Humidity (IVIS)              1                     !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                              Default: T           ! LCOMPRS = F !
```

```
*
 0 = Do not create file, 1 = create file


 LINE PRINTER OUTPUT OPTIONS:

    Print concentrations (ICPRT)     Default: 0          ! ICPRT =  0   !
    Print dry fluxes (IDPRT)         Default: 0          ! IDPRT =  0   !
    Print wet fluxes (IWPRT)         Default: 0          ! IWPRT =  0   !
    (0 = Do not print, 1 = Print)

    Concentration print interval
    (ICFRQ) in hours                 Default: 1          ! ICFRQ =  1   !
    Dry flux print interval
    (IDFRQ) in hours                 Default: 1          ! IDFRQ =  1   !
    Wet flux print interval
    (IWFRQ) in hours                 Default: 1          ! IWFRQ =  1   !

    Units for Line Printer Output
    (IPRTU)                          Default: 1          ! IPRTU =  1   !
                      for              for
                 Concentration     Deposition
        1 =          g/m**3           g/m**2/s
        2 =         mg/m**3          mg/m**2/s
        3 =         ug/m**3          ug/m**2/s
        4 =         ng/m**3          ng/m**2/s
        5 =       Odour Units

    Messages tracking progress of    Default: 1          ! IMESG =  1   !
    run written to the screen ?
    (IMESG) -- 0=no, 1=yes


  SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 -------- CONCENTRATIONS ---------   ----------- DRY FLUXES -----------   --------
- WET FLUXES ----------
   SPECIES
   /GROUP          PRINTED ?       SAVED ON DISK ?      PRINTED ?       SAVED ON DISK ?
PRINTED ?     SAVED ON DISK ?
   -------      ---------------------------------   ---------------------------------   --------
-----------------------
!          SO2 =          0,              1,              0,              1,              0,
1   !
!          SO4 =          0,              1,              0,              1,              0,
1   !
!           NO =          0,              1,              0,              1,              0,
1   !
!          NO2 =          0,              1,              0,              1,              0,
1   !
!         HNO3 =          0,              1,              0,              1,              0,
1   !
!          NO3 =          0,              1,              0,              1,              0,
1   !
!        PM2.5 =          0,              1,              0,              1,              0,
1   !
!         PM10 =          0,              1,              0,              1,              0,
1   !

  OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

    Logical for debug output
    (LDEBUG)                                 Default: F      ! LDEBUG = F !

    Number of puffs to track
    (NPFDEB)                                 Default: 1      ! NPFDEB =  1  !

    Met. period to start output
    (NN1)                                    Default: 1      ! NN1 =  1   !

    Met. period to end output
    (NN2)                                    Default: 10     ! NN2 =  10  !

!END!
```

```
--------------------------------------------------------------------------------

INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)       Default: 0     ! NHILL =  0   !

       Number of special complex terrain
       receptors  (NCTREC)                      Default: 0     ! NCTREC =  0   !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                                  No Default     ! MHILL =  2   !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1. !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1. !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0.0E00 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0.0E00 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL           XC         YC        THETAH   ZGRID   RELIEF     EXPO 1     EXPO 2    SCALE 1     SCALE 2
AMAX1      AMAX2
 NO.           (km)       (km)      (deg.)    (m)      (m)        (m)        (m)        (m)         (m)
(m)        (m)
----           ----       ----      ------   -----   ------     ------     ------    --------    --------
-----      -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT          YRCT          ZRCT          XHH
                      (km)          (km)           (m)
                     ------        -----        ------         ----


--------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
```

```
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------

INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES      DIFFUSIVITY       ALPHA STAR       REACTIVITY     MESOPHYLL RESISTANCE      HENRY'S
LAW COEFFICIENT
       NAME         (cm**2/s)                                              (s/cm)
(dimensionless)
    . -------      -----------       ----------       ----------     --------------------      -------
----------------
      !SO2   =      0.1509,           1.00E3 ,          8.0 ,             0.0,                   4.0e-2
!
      !NO    =      0.1656,           1.00   ,          8.0 ,             5.0,                   3.5
!
      !NO2   =      0.1656,           1.00   ,          8.0 ,             5.0,                   3.5
!
      !HNO3  =      0.1628,           1.00   ,        180.0 ,             0.0,                   8.0e-8
!
!END!

-------------------------------------------------------------------------------

INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES       GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME              DIAMETER                   DEVIATION
                         (microns)                  (microns)
      -------       --------------------       ------------------
      ! SO4 =              0.48,                      2.00 !
      ! NO3 =              0.48,                      2.00 !
      ! PM10 =             2.0,                       2.00 !
      ! PM2.5 =            0.48,                      2.00 !
!END!

-------------------------------------------------------------------------------

INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance    (RCUTR)   (s/cm)    !  RCUTR = 30. !
     Reference ground resistance     (RGR)     (s/cm)    !    RGR = 10. !
     Reference pollutant reactivity  (REACTR)            ! REACTR = 8. !
```

```
     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                          Default: 9     !   NINT =  9  !

     Vegetation state in unirrigated areas (IVEG)     !   IVEG =  3  !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------

                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------
!         SO2 =          3.0E-05,             0.0     !
!         SO4 =         10.0E-05,             3.0E-05 !
!         NO  =          0.0    ,             0.0     !
!         NO2 =          0.0    ,             0.0     !
!        HNO3 =          6.0E-05,             0.0     !
!         NO3 =         10.0E-05,             3.0E-05 !
!        PM10 =         10.0E-05,             3.0E-05 !
!       PM2.5 =         10.0E-05,             3.0E-05 !

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 11 -- Chemistry Parameters
---------------

     Ozone data input option (MOZ)     Default: 1          ! MOZ =  1   !
     (Used only if MCHEM = 1 or 3)
        0 = use a constant background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Background ozone concentration
     (BCKO3) in ppb                    Default: 80.        ! BCKO3 = 40. !
     (Used only if MCHEM = 1 or 3 and
      MOZ = 0 or (MOZ = 1 and all hourly
      O3 data missing)

     Background ammonia concentration
     (BCKNH3) in ppb                   Default: 10.        ! BCKNH3 = 1.1 !

     Nighttime SO2 loss rate (RNITE1)
     in percent/hour                   Default: 0.2        ! RNITE1 = 0.2 !

     Nighttime NOx loss rate (RNITE2)
     in percent/hour                   Default: 2.0        ! RNITE2 = 2. !

     Nighttime HNO3 formation rate (RNITE3)
     in percent/hour                   Default: 2.0        ! RNITE3 = 2. !

!END!

-------------------------------------------------------------------------------


INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------
```

```
Horizontal size of puff (m) beyond which
time-dependent dispersion equations (Heffter)
are used to determine sigma-y and
sigma-z (SYTDEP)                          Default: 550.   ! SYTDEP = 5.5E02 !

Switch for using Heffter equation for sigma z
as above (0 = Not use Heffter; 1 = use Heffter
(MHFTSZ)                                  Default: 0      ! MHFTSZ =  0   !

Stability class used to determine plume
growth rates for puffs above the boundary
layer (JSUP)                              Default: 5      ! JSUP =  5   !

Vertical dispersion constant for stable
conditions (k1 in Eqn. 2.7-3)  (CONK1)    Default: 0.01   ! CONK1 = 0.01 !

Vertical dispersion constant for neutral/
unstable conditions (k2 in Eqn. 2.7-4)
(CONK2)                                   Default: 0.1    ! CONK2 = 0.1 !

Factor for determining Transition-point from
Schulman-Scire to Huber-Snyder Building Downwash
scheme (SS used for Hs < Hb + TBD * HL)
(TBD)                                     Default: 0.5    ! TBD = 0.5 !
   TBD < 0   ==> always use Huber-Snyder
   TBD = 1.5 ==> always use Schulman-Scire
   TBD = 0.5 ==> ISC Transition-point

Range of land use categories for which
urban dispersion is assumed
(IURB1, IURB2)                            Default: 10     ! IURB1 =  10  !
                                                   19     ! IURB2 =  19  !

Site characterization parameters for single-point Met data files ---------
(needed for METFM = 2,3,4)

   Land use category for modeling domain
   (ILANDUIN)                             Default: 20     ! ILANDUIN =  20  !

   Roughness length (m) for modeling domain
   (Z0IN)                                 Default: 0.25   ! Z0IN = 0.25 !

   Leaf area index for modeling domain
   (XLAIIN)                               Default: 3.0    ! XLAIIN = 3. !

Specialized information for interpreting single-point Met data files -----

   Anemometer height (m) (Used only if METFM = 2,3)
   (ANEMHT)                               Default: 10.    ! ANEMHT = 10. !

   Form of lateral turbulance data in PROFILE.DAT file
   (Used only if METFM = 4 or MTURBVW = 1 or 3)
   (ISIGMAV)                              Default: 1      ! ISIGMAV =  1  !
       0 = read sigma-theta
       1 = read sigma-v

   Choice of mixing heights (Used only if METFM = 4)
   (IMIXCTDM)                             Default: 0      ! IMIXCTDM =  0  !
       0 = read PREDICTED mixing heights
       1 = read OBSERVED mixing heights

Maximum length of a slug (met. grid units)
(XMXLEN)                                  Default: 1.0    ! XMXLEN = 1. !

Maximum travel distance of a puff/slug (in
grid units) during one sampling step
(XSAMLEN)                                 Default: 1.0    ! XSAMLEN = 1. !

Maximum Number of slugs/puffs release from
one source during one time step
(MXNEW)                                   Default: 99     ! MXNEW =  99   !

Maximum Number of sampling steps for
one puff/slug during one time step
(MXSAM)                                   Default: 99     ! MXSAM =  99   !
```

```
Minimum sigma y for a new puff/slug (m)
(SYMIN)                                  Default: 0.01    ! SYMIN = 0.01  !

Minimum sigma z for a new puff/slug (m)
(SZMIN)                                  Default: 0.01    ! SZMIN = 0.01  !

Minimum turbulence sigma-v (m/s)
(SVMIN)                                  Default: 0.50    ! SVMIN = 0.5   !

Minimum turbulence sigma-w (m/s)
(SVMIN)                                  Default: 0.016   ! SWMIN = 0.016 !

Divergence criterion for dw/dz in met cell
used to initiate adjustment for horizontal
convergence (1/s)
(CDIV)                                   Default: 0.010   ! CDIV = 0.01   !

Minimum wind speed (m/s) allowed for
non-calm conditions. Also used as minimum
speed returned when using power-law
extrapolation toward surface
(WSCALM)                                 Default: 1.0     ! WSCALM = 1. !

Maximum mixing height (m)
(XMAXZI)                                 Default: 3000.   ! XMAXZI = 3000. !

Minimum mixing height (m)
(XMINZI)                                 Default: 50.     ! XMINZI = 50. !

Default wind speed classes --
5 upper bounds (m/s) are entered;
the 6th class has no upper limit
(WSCAT(5))                       Default   :
                                 ISC RURAL : 1.54, 3.09, 5.14, 8.23, 10,8 (10.8+)

                           Wind Speed Class :  1     2     3     4     5     6
                                               ---   ---   ---   ---   ---   ---
                                    ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

Default wind speed profile power-law
exponents for stabilities 1-6
(PLX0(6))                        Default   : ISC RURAL values
                                 ISC RURAL : .07, .07, .10, .15, .35, .55
                                 ISC URBAN : .15, .15, .20, .25, .30, .30

                            Stability Class :  A     B     C     D     E     F
                                               ---   ---   ---   ---   ---   ---
                                      ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !

Default potential temperature gradient
for stable classes E, F (degK/m)
(PTG0(2))                        Default: 0.020, 0.035
                                    ! PTG0 = 0.020,   0.035 !

Default plume path coefficients for
each stability class (used when option
for partial plume height terrain adjustment
is selected -- MCTADJ=3)
(PPC(6))                      Stability Class :  A     B     C     D     E     F
                                 Default  PPC : .50,  .50,  .50,  .50,  .35,  .35
                                               ---   ---   ---   ---   ---   ---
                                      !  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !

Slug-to-puff transition criterion factor
equal to sigma-y/length of slug
(SL2PF)                                  Default: 10.       ! SL2PF = 10. !

Puff-splitting control variables -----------------------

  Number of puffs that result every time a puff
  is split - nsplit=2 means that 1 puff splits
  into 2
  (NSPLIT)                               Default:   3       ! NSPLIT =  3  !
```

```
      Time(s) of a day when split puffs are eligible to
      be split once again; this is typically set once
      per day, around sunset before nocturnal shear develops.
      24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
      0=do not re-split    1=eligible for re-split
      (IRESPLIT(24))                    Default:  Hour 17 = 1
      !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

      Split is allowed only if last hour's mixing
      height (m) exceeds a minimum value
      (ZISPLIT)                         Default: 100.       ! ZISPLIT = 100. !

      Split is allowed only if ratio of last hour's
      mixing ht to the maximum mixing ht experienced
      by the puff is less than a maximum value (this
      postpones a split until a nocturnal layer develops)
      (ROLDMAX)                         Default: 0.25       ! ROLDMAX = 0.25 !

    Integration control variables ------------------------

      Fractional convergence criterion for numerical SLUG
      sampling integration
      (EPSSLUG)                         Default:   1.0e-04  ! EPSSLUG = 1.0E-04 !

      Fractional convergence criterion for numerical AREA
      source integration
      (EPSAREA)                         Default:   1.0e-06  ! EPSAREA = 1.0E-06 !
!END!.

-------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
---------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  1  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =  1  !
          1 =        g/s
          2 =       kg/hr
          3 =       lb/hr
          4 =     tons/yr
          5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
          6 =     Odour Unit * m**3/min

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                    a
          POINT SOURCE: CONSTANT DATA
          ---------------------------
                                                                    b          c
  Source       X UTM      Y UTM      Stack   Base      Stack     Exit  Exit     Bldg.  Emission
```

```
  No.      Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.    Dwash   Rates
             (km)       (km)       (m)       (m)       (m)  (m/s) (deg. K)
 ------   ---------- ---------- ------  ------   -------- ----- -------- ----- --------
   1 ! SRCNAM = 1 !
   1 ! X =   -92.82,    12.439,     14., 2150.,      1.19, 80.77, 765.93,   1., 1.386E-02, 0.0,
4.239176,
       0.72223, 0.0, 0.0,7.2072E-01, 7.2072E-01 !

!END!
```

---

a
Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

b
0. = No building downwash modeled, 1. = downwash modeled
NOTE: must be entered as a REAL number (i.e., with decimal point)

c
An emission rate must be entered for every pollutant modeled. Enter emission rate of zero for secondary pollutants that are modeled, but not emitted. Units are specified by IPTU (e.g. 1 for g/s).

Subgroup (13c)

BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH

```
Source                                                                        a
 No.       Effective building width and height (in meters) every 10 degrees
------     ------------------------------------------------------------------
 1    ! SRCNAM  =   1 !
 1    ! HEIGHT  =  9.14,   9.14,   9.14,   9.14,   9.14,   9.14,
                   9.14,   9.14,   9.14,   9.14,   9.14,   9.14,
                   9.14,   9.14,   9.14,   9.14,   9.14,   9.14,
                   9.14,   9.14,   9.14,   9.14,   9.14,   9.14,
                   9.14,   9.14,   9.14,   9.14,   9.14,   9.14,
                   9.14,   9.14,   9.14,   9.14,   9.14,   9.14!
 1    ! WIDTH   =  92.7,   91.14,   86.81,   79.84,   70.45,   58.92,
                   45.6,   30.89,   15.24,   30.89,   45.6,   58.92,
                   70.45,   79.84,   86.81,   91.14,   92.7,   91.44,
                   92.7,   91.14,   86.81,   79.84,   70.45,   58.92,
                   45.6,   30.89,   15.24,   30.89,   45.6,   58.92,
                   70.45,   79.84,   86.81,   91.14,   92.7,   91.44!
!END!
```

---

a
Each pair of width and height values is treated as a separate input subgroup and therefore must end with an input group terminator.

Subgroup (13d)

---

a
POINT SOURCE: VARIABLE EMISSIONS DATA

Use this subgroup to describe temporal variations in the emission rates given in 13b. Factors entered multiply the rates in 13b. Skip sources here that have constant emissions. For more elaborate variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

IVARY determines the type of variation, and is source-specific:
(IVARY) Default: 0

- 0 = Constant
- 1 = Diurnal cycle (24 scaling factors: hours 1-24)
- 2 = Monthly cycle (12 scaling factors: months 1-12)
- 3 = Hour & Season (4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)

```
          4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                   first group is Stability Class A,
                                   and the speed classes have upper
                                   bounds (m/s) defined in Group 12
          5 =       Temperature   (12 scaling factors, where temperature
                                   classes have upper bounds (C) of:
                                   0, 5, 10, 15, 20, 25, 30, 35, 40,
                                   45, 50, 50+)
```

---

a
Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

```
INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
---------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  0   !

     Units used for area source
     emissions below          (IARU)       Default: 1  !  IARU =   3  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                    a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                              b
Source           Effect.     Base       Initial     Emission
 No.             Height    Elevation    Sigma z      Rates
                   (m)       (m)          (m)
-------          ------    ------     --------    ---------
```

---

a
Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

b
An emission rate must be entered for every pollutant modeled. Enter emission rate of zero for secondary pollutants that are modeled, but not emitted. Units are specified by IARU (e.g. 1 for g/m**2/s).

```
Subgroup (14c)
---------------

           COORDINATES (UTM-km) FOR EACH VERTEX(4) OF EACH POLYGON
           ------------------------------------------------------
Source                                                              a
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------

--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                          a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          ------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
----------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                          No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)    No default   ! NLINES =  0  !

     Units used for line source
     emissions below            (ILNU)          Default: 1  !  ILNU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
```

```
          5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
          6 =     Odour Unit * m**3/min

    Number of source-species
    combinations with variable
    emissions scaling factors
    provided below in (15c)        (NSLN1) Default: 0  !  NSLN1 =  0  !

    Maximum number of segments used to model
    each line (MXNSEG)                                 Default: 7   ! MXNSEG =  7  !

    The following variables are required only if NLINES > 0.  They are
    used in the buoyant line source plume rise calculations.

       Number of distances at which                    Default: 6   ! NLRISE =  6  !
       transitional rise is computed

       Average line source length (XL)                 No default   ! XL = 0. !
                                                       (in meters)

       Average height of line source height (HBL)      No default   ! HBL = 0. !
                                                       (in meters)

       Average building width (WBL)                    No default   ! WBL = 0. !
                                                       (in meters)

       Average line source width (WML)                 No default   ! WML = 0. !
                                                       (in meters)

       Average separation between buildings (DXL)      No default   ! DXL = 0. !
                                                       (in meters)

       Average buoyancy parameter (FPRIMEL)            No default   ! FPRIMEL = 0. !
                                                       (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------

          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------
                                                                                  a
Source     Beg. X      Beg. Y      End. X      End. Y     Release     Base        Emission
 No.     Coordinate  Coordinate  Coordinate  Coordinate  Height    Elevation      Rates
           (km)        (km)        (km)        (km)       (m)       (m)
------   ----------  ----------  ---------  ----------  -------   ---------    ---------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).

---------------
Subgroup (15c)
---------------
                                                    a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                                  Default: 0
          0 =       Constant
```

```
          1 =       Diurnal cycle (24 scaling factors: hours 1-24)
          2 =       Monthly cycle (12 scaling factors: months 1-12)
          3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                   where first group is DEC-JAN-FEB)
          4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                   first group is Stability Class A,
                                   and the speed classes have upper
                                   bounds (m/s) defined in Group 12
          5 =       Temperature   (12 scaling factors, where temperature
                                   classes have upper bounds (C) of:
                                   0, 5, 10, 15, 20, 25, 30, 35, 40,
                                   45, 50, 50+)
```

---

a
Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

```
INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !

     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
          1 =        g/s
          2 =       kg/hr
          3 =       lb/hr
          4 =     tons/yr
          5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
          6 =     Odour Unit * m**3/min

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Gridded volume source data
     used ? (IGRDVL)                         No default  ! IGRDVL =  0   !
        0 = no
        1 = yes (gridded volume source
            emissions read from the file:
            VOLEM.DAT)

     The following parameters apply to the data in the
     gridded volume source emissions file (VOLEM.DAT)

       -  Effective height of emissions
          (VEFFHT) in meters               No default  ! VEFFHT =  0. !

       -  Initial sigma y (VSIGYI) in
          meters                           No default  ! VSIGYI =  0. !

       -  Initial sigma z (VSIGZI) in
          meters                           No default  ! VSIGZI =  0. !

!END!

---------------
Subgroup (16b)
---------------
                                    a
          VOLUME SOURCE: CONSTANT DATA
          ----------------------------
```

X UTM Coordinate (km)	Y UTM Coordinate (km)	Effect. Height (m)	Base Elevation (m)	Initial Sigma y (m)	Initial Sigma z (m)	Emission Rates [b]

---

[a] Data for each source are treated as a separate input subgroup and therefore must end with an input group terminator.

[b] An emission rate must be entered for every pollutant modeled. Enter emission rate of zero for secondary pollutants that are modeled, but not emitted. Units are specified by IVLU (e.g. 1 for g/s).

Subgroup (16c)

VOLUME SOURCE: VARIABLE EMISSIONS DATA [a]

Use this subgroup to describe temporal variations in the emission rates given in 16b. Factors entered multiply the rates in 16b. Skip sources here that have constant emissions. For more elaborate variation in source parameters, use VOLEM.DAT and IGRDVL = 1.

IVARY determines the type of variation, and is source-specific:
(IVARY) Default: 0

0 =	Constant	
1 =	Diurnal cycle	(24 scaling factors: hours 1-24)
2 =	Monthly cycle	(12 scaling factors: months 1-12)
3 =	Hour & Season	(4 groups of 24 hourly scaling factors, where first group is DEC-JAN-FEB)
4 =	Speed & Stab.	(6 groups of 6 scaling factors, where first group is Stability Class A, and the speed classes have upper bounds (m/s) defined in Group 12
5 =	Temperature	(12 scaling factors, where temperature classes have upper bounds (C) of: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 50+)

---

[a] Data for each species are treated as a separate input subgroup and therefore must end with an input group terminator.

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information

---

Subgroup (17a)

Number of non-gridded receptors (NREC) No default ! NREC = 281 !

!END!

Subgroup (17b)

NON-GRIDDED (DISCRETE) RECEPTOR DATA [a]

X UTM	Y UTM	Ground

Receptor No.		Coordinate (km)	Coordinate (km)	Elevation (m)	
1	! X=	-180.9,	138.4,	636.5!	!END!
2	! X=	-179.6,	130.9,	620.6!	!END!
3	! X=	-182.7,	123.0,	693.0!	!END!

FOR THE SAKE OF BREVITY, ALL RECEPTOR LOCATIONS ARE NOT RERPRODUCED (SEE FIGURE 4-3)

279	! X=	-35.9,	12.1,	650.8!	!END!
280	! X=	-35.0,	11.9,	650.8!	!END!
281	! X=	-35.3,	9.8,	674.9!	!END!

---

a
Data for each receptor are treated as a separate input subgroup and therefore must end with an input group terminator.